

CLAIMS

1. An optical device for providing optical amplification comprising a substrate, and
5 a radiation sensitive polymer structure provided on the substrate in a predetermined shape defined by a number of sidewalls, n , and being doped with an optically active medium, wherein the sidewalls of the structure form a cavity resonator so that an electromagnetic wave upon pumping of the device is emitted laterally.
- 10 2. An optical device for providing optical amplification comprising a substrate, and a radiation sensitive polymer structure provided on the substrate in a predetermined shape defined by a number of sidewalls, n , and being doped with an optically active medium, wherein the shape and/or at least one material provided at least along a part of at least
15 one sidewall of the structure are selected so that an electromagnetic wave propagating in the structure will experience total internal reflection when incident on no more than $n-1$ sidewalls.
- 20 3. An optical device according to claims 1 or 2, wherein the electromagnetic wave propagating in the structure is incident at the no more than $n-1$ sidewalls at an angle greater than a critical angle.
- 25 4. An optical device according to any of claims 1-3, wherein an electromagnetic wave is emitted from at least a part of at least one sidewall of the structure upon pumping of the device.
5. An optical device according to claim 1-4, wherein the at least one material comprises a first and/or a second material.
- 30 6. An optical device according to any of claims 1-5, wherein total internal reflection is obtained by providing the first material along a first number of sidewalls and providing a second material along a second number of sidewalls, the first and second materials and the angles between the sidewalls being selected so as to provide total internal reflection due to an incident angle of a propagating electromagnetic wave being greater than the
35 critical angle for a propagating electromagnetic wave incident on the first number of sidewalls, whereas the second material is selected so that the propagating electromagnetic wave incident on the second number of sidewalls are incident under an angle being less than the critical angle, so as to allow for outputting an electromagnetic wave from the second number of sidewalls.

7. An optical device according to any of claims 1-6, wherein the second material is provided along at least a part of at least one sidewall for allowing for emission of an electromagnetic wave from the structure.
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8. An optical device according to claim 7, wherein the shape is rectangular and wherein the critical angle of the at least part of the at least one sidewall is altered due to the presence of the at second material.
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9. An optical device according to any of claims 1-9, wherein the device is optically pumped.
10. An optical device according to any of claims 2-9, wherein the sidewalls of the structure forms a cavity resonator.
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11. An optical device according to claims 1 or 10, wherein the cavity resonator is a laser cavity.
12. An optical device according to any of claims 1 or 4-11, wherein the emitted electromagnetic wave is a coherent electromagnetic wave.
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13. An optical device according to claim 12, wherein the length of the cavity is in the order of the wavelength of the propagating electromagnetic wave.
14. An optical device according to claims 12 or 13, wherein the coherent electromagnetic
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15. An optical device according to any claims 1 or 4-14, wherein the emitted electromagnetic wave is emitted parallel to the substrate.
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16. An optical device according to any of claims 4-15, wherein the electromagnetic wave is emitted laterally.
17. An optical device according to any of claims 1 or 10-16, wherein the wavelength of the emitted electromagnetic wave is determined as a function of concentration of optically
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- active medium in the polymer and resonator cavity length.
18. An optical device according to claim 1-17, wherein the radiation sensitive material has a refractive index higher than the refractive index of the at least one material.

19. An optical device according to any of claims 1-18, wherein the radiation sensitive polymer is definable by photo lithography, e-beam lithography, X-ray lithography, ion-beam lithography, or hot embossing or nano-imprinting lithographies.
- 5 20. An optical device according to any of claims 1 or 10-19, wherein the device comprises an array of cavity resonators.
21. An optical device according to claim 20, wherein at least two cavity resonators in the array are coupled.
- 10 22. An optical device according to any of claims 1-21, wherein the shape is circular or elliptical.
23. An optical device according to any of claims 1-22, wherein the shape is a polygon.
- 15 24. An optical device according to claim 23, wherein the shape is a trapezoid.
25. An optical device according to claim 24, wherein the electromagnetic wave propagating in the cavity is incident at an angle greater than the critical angle at three sidewalls of the trapezoid.
- 20 26. An optical device according to claim 23, wherein the shape is a triangle.
27. An optical device according to any of claims 2-26, wherein the at least one material is air, liquid or polymer.
- 25 28. An optical device according to any of claims 6-27, wherein the second material is provided along at least a part of at least one sidewall for allowing for emission of an electromagnetic wave from the structure.
- 30 29. An optical device according to claim 23, wherein the shape is rectangular and wherein the critical angle of the at least part of the at least one sidewall is altered due to the presence of the at second material.
- 35 30. An optical device according to any of claims 1-29, wherein the polymer is a solid polymer.
31. An optical device according to any of claims 1-30, wherein the radiation sensitive polymer is a negative tone resist.

32. An optical device according to any of claims 1-30, wherein the radiation sensitive polymer is epoxy based.
- 5 33. An optical device according to any of claims 1-30, wherein the radiation sensitive polymer is photo-definable.
34. An optical device according to claim 33, wherein the polymer is photo-definable by an electromagnetic source having a wavelength above 250 nm.
- 10 35. An optical device according to claim 34, wherein the polymer is photo-definable by an electromagnetic source having a wavelength of about 370 nm (i-line)
36. An optical device according to any of claims 1-35, wherein the optically active medium
15 comprises organic compounds.
37. An optical device according to any of claims 1-36, wherein the optically active medium comprises organic compounds, rare earths, such as Erbium, nanoparticles, or quatum dots.
- 20 38. An optical device according to claim 37, wherein the optically active medium comprises laser dye(s).
39. An optical device according to claim 38, wherein the dye comprises Rhodamine or Couramine
- 25 40. An optical device according to claim 38, wherein the dye is Rhodamine 6G R4127.
41. An optical device according to any of claims 38-40, wherein the dye concentration in the polymer is above 1,1 $\mu\text{mole}/\text{cm}^3$.
- 30 42. An optical device according to any of claims 1-41, wherein the substrate is a metal substrate, a semiconductor substrate, a ceramic substrate, a glass substrate, such as a Pyrex substrate or any combination of such materials.
- 35 43. An optical device according to any of claims 1-42, wherein the structure has a height above 2 μm .
44. An optical device for providing optical amplification, the device comprises a substrate,

a photo-definable polymer structure provided on the substrate in a predetermined shape and being doped with an optically active medium.

45. An optical device for providing optical amplification, the device comprises
5 a substrate,
a photo-definable polymer structure provided on the substrate in a predetermined shape and being doped with an optically active medium,
wherein the photo-definable polymer is a negative tone photo-definable polymer.

10 46. An optical device for providing optical amplification upon pumping, the device comprises
a substrate,
a photo-definable polymer structure provided on the substrate in a predetermined shape and being doped with an optically active medium,
15 wherein the photo-definable polymer is an epoxy based photo-definable polymer.

47. An optical device according to any of claims 1-46, wherein the photo-definable polymer is SU-8.

20 48. An optical device according to any of claims 44-46, further comprising any features of claims 1-43.

49. A method of manufacturing an optically active medium, the method comprising the steps of:
25 providing a substrate,
providing a radiation sensitive polymer being doped with an optically active medium on the substrate,
defining a predetermined structure in the radiation sensitive polymer by lithography.

30 50. A method according to claim 49, wherein the step of providing the radiation sensitive polymer on the substrate comprises the step of spin-coating the substrate with the radiation sensitive polymer being doped with an optically active medium.

51. A method according to claim 50, wherein the step of
35 defining the structure comprises the steps of
exposing the spin-coated polymer in a predetermined pattern,
developing the predetermined pattern to form at least one polymer structure.

52. A method according to claim 52, wherein the step of defining the structure further comprises the step of soft-baking the polymer prior to the exposing step.
53. A method according to claims 51 or 52, wherein the step of defining the structure
5 further comprises the step of post exposure baking the polymer after the exposing step.
54. A method according any of claims 51-53, wherein the step of developing comprises the step of using a wet developer for developing the pattern.
- 10 55. A method according to any of claims 49-54, wherein the optically active medium is soluted in the polymer prior to providing the polymer to the substrate.
56. A method for laterally emitting an electromagnetic wave, the method comprises the steps of
15 providing a radiation sensitive polymer being doped with an optically active medium on a substrate,
defining a structure in the polymer by exposing the polymer to radiation in a predetermined pattern,
developing the predetermined pattern to obtain at least one structure in the polymer,
20 pumping the structure by a pump source so as to provide activation of the optically active medium,
laterally emitting an electromagnetic wave.
57. A micro system comprising at least one optical device according to any of claims 1-56.
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58. A micro system according to claim 57, further comprising at least one waveguide channel.
59. A micro system according to claim 57 or 58, wherein the at least one waveguide
30 channel and the polymer structure of the optical device is fabricated in the same polymer material.
60. A micro system according to any of claims 57-59, wherein the polymer structure is
35 waveguide channel.